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The microflora of the alimentary canal of *Oppia nitens* (Acarina, Oribatei)[1])

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With 4 figures

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1. Introduction

In estimating the role of moss mites in the processes of humification and mineralization of plant remains the interaction between these Acarina and bacteria should not be omitted, considering the great activity of microorganisms in the decomposition of organic matter.

The results hitherto obtained (Prusinkiewicz, Stefaniak and Seniczak 1975; Stefaniak and Seniczak 1976) have demonstrated that in the alimentary canal of such species as: *Achipteria coleoptrata* (L.), *Phthiracarus piger* (Scopoli), *Tectocepheus velatus* (Michael), *Tropacarus carinatus* (C. L. Koch) and *Trhypochthonius cladonicola* (Willmann), there occurs a rich and highly differentiated bacterial microflora. From among the species studied in our laboratories only *Oppiella obsoleta* (Paoli) of the family Oppiidae shows only fungi and no bacteria in its alimentary canal.

The different character of the alimentary canal microflora in *Oppiella obsoleta* induced us to study in detail other members of the family Oppiidae. The species studied in the first place was *Oppia nitens* C. L. Koch. It is generally polyphagous, though it also shows strong propensities towards necrophagy. In relation to non-active developmental forms of mites (eggs, moulting juvenile stages with delicate cuticle) *Oppia nitens* is even predacious. For these reasons the species in question seems to be an interesting object of studies on the effect of the quality of food on the composition of the alimentary canal microflora.

2. Material and methods

The material for study was collected in April 1976, in the litter under yew-trees *(Taxus baccata)* in Sołacz Park in Poznań. It contained juvenile and adult specimens of *Oppia nitens*. Part of the juvenile (tritonymphs) and adult individuals as well as their feeding ground were subjected to microbiological analysis immediately after bringing the samples from the field. The remaining specimens were reared in self-constructed chambers (Seniczak 1972). These were divided into three experimental groups: the first one was fed on algae *(Protococcus viridis)*, the second on carrion (dead mites mainly of the suborder Trombidiformes and Collembola), and the third on human epidermis (from the experimenter's fingers). Each group consisted of 10 juvenile and 10 adult specimens was examined after one month's rearing, in juvenile forms after transition to the tritonymph stage.

The method used in the experiment was the one worked out previously (Prusinkiewicz, Stefaniak and Seniczak 1975) and modified by Stefaniak and Seniczak (1976). The experimental conditions were the same as in earlier studies, so that the results obtained for various moss-mite species may be compared.

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1) The present work was partly supported by the Committee of Ecology of the Polish Academy of Sciences in Warsaw.

3. Results

The alimentary canal microflora in juvenile stages of *Oppia nitens* was much more abundant and more active than in adult specimens (Table 1). In juvenile individuals feeding in natural habitat the microflora was 3 times as numerous as in adults. In laboratory grown specimens fed on algae (Fig. 1, 2) and on dead mites and Collembola (Fig. 3, 4) the numbers were respectively 30 and 40 times as large as in adult mites. The observation made on the developmental stages of *Achipteria coleoptrata* (STEFANIAK and SENICZAK 1976) has then been confirmed.

Among the bacteria isolated from the alimentary canal of *Oppia nitens* aerobic and facultatively anaerobic rod-shaped forms dominated. Among Actinomycetes have been found forms producing white compact aerial mycelium *(Streptomyces* sp.*)* and forms which do not produce aerial mycelium, but give off dark melanine pigment into the medium *(Nocardia* sp.*)*. Some of the characteristics of the isolated strains are presented in Tables 2—5. Besides a characteristic of the microorganisms isolated from the alimentary canal of the mites, the tables also give a characteristic of the microflora dominating in their feeding habitat.

The isolated strains were also tested on their activity in decomposing gelatin, starch, cellulose, pectins and chitin. In the alimentary canals of mites feeding in natural habitat (Table 2) a strongly amylolytic microflora predominated. Most of the strains also showed a capacity for decomposing cellulose, and some, moreover, pectins. In both juvenile and adult individuals of this group of mites no bacteria capable of decomposing chitin have been found, although such bacteria occurred in their natural habitat.

Similar properties have been found in the microflora community isolated from the alimentary canal of mites fed on algae (Table 3). In this community no pectino- and chitinolytic forms have been found, though such forms occasionally occurred on algae.

The moss mites fed on dead Acarina and Collembola (Table 5) and on epidermis, on the other hand, possessed in the first place a microflora showing strong proteolytic activity and vigorous activity in decomposing chitin. In individuals fed on dead Acarina and Collembola no pectinolytic microflora has been found. A capacity for pectin decomposition, on the other hand, was demonstrated by some strains isolated from the alimentary canals of individuals fed on epidermis.

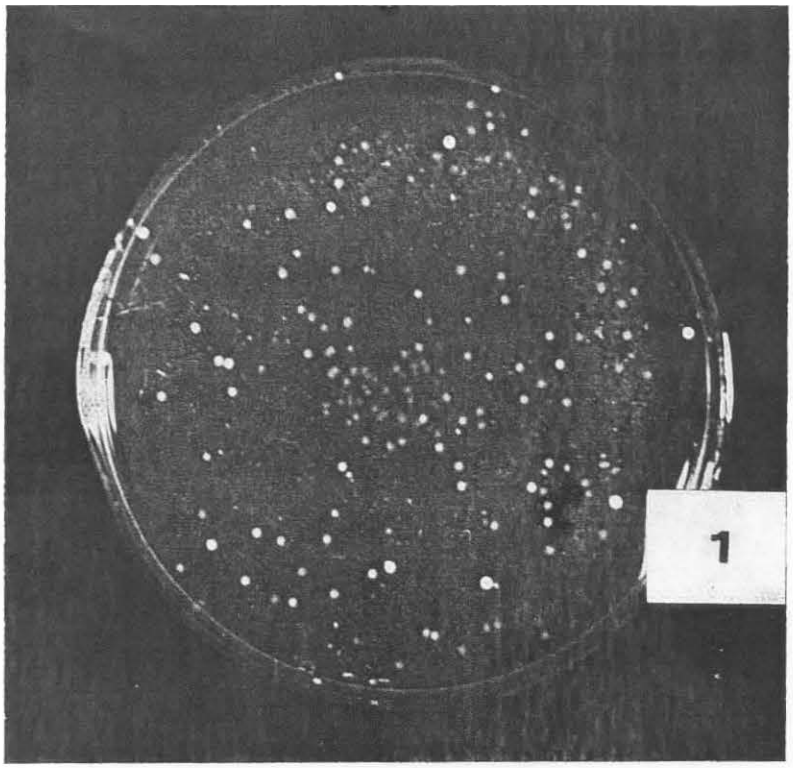
The microflora in the alimentary canal of *Oppia nitens* generally showed low activity towards carbohydrates (glucose, fructose, lactose, saccharose, maltose, glycerol) irrespective of the quality of food and the development stage of the mites.

Certain isolated strains, in particular the chitinolytic rods and the Actinomycetes, strongly changed the *p*H of the culture medium (*p*H increased from 7.0 to 8.0—9.0). It may therefore be presumed that the alimentary canal contents also show a basic, or at least neutral reaction. This in turn might explain the almost complete absence of fungal microflora from the mites under study (Table 6). No fungi have been found even in individuals feeding in the natural habitat, in spite of the presence there of an abundant fungal flora. Similar relationships have been found earlier (PRUSINKIEWICZ, STEFANIAK and SENICZAK 1975) in studies of the alimentary canal microflora and feeding habitat of the moss mite *Phthiracarus piger*. The absence of fungi may also result from complete digestion of these microorganisms in the alimentary canal of moss mites.

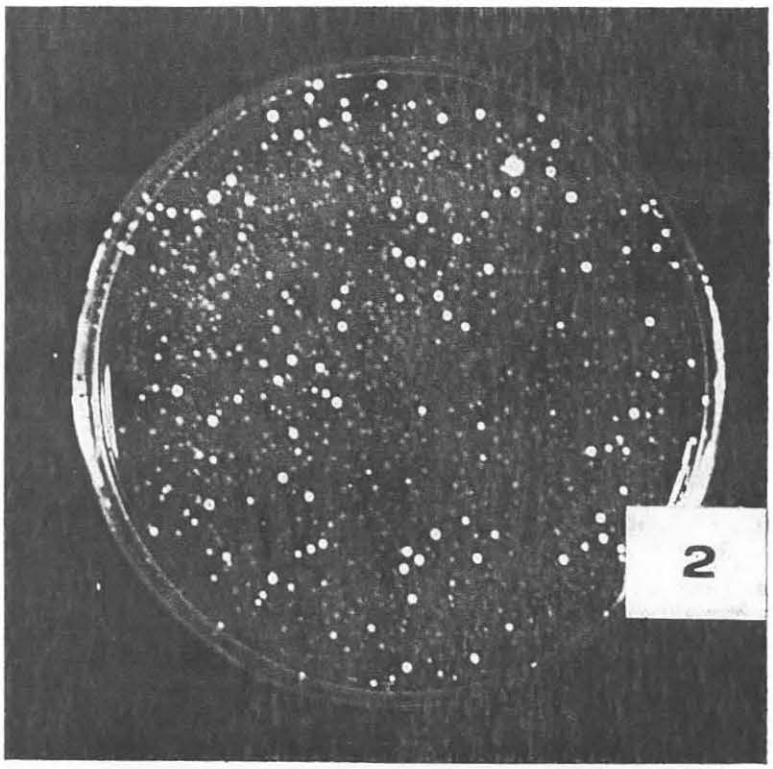
Table 1. Colony counts of microorganisms isolated from the alimentary canal of *Oppia nitens* fed on different food

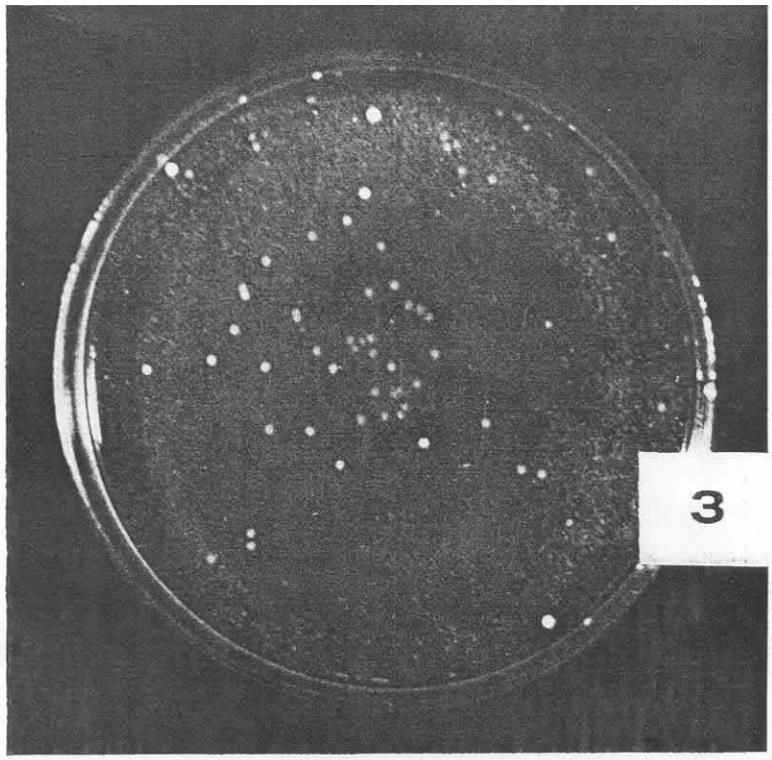
Colonies of	*Oppia nitens* fed:							
	in nature		on algae		on carrion		on epidermis	
	adult	juvenile	adult	juvenile	adult	juvenile	adult	juvenile
Bacteria	21.2	66.8	20.3	758.6	19.2	862.2	10.8	24.4
Actinomycetes	4.3	18.6	1.9	39.8	3.4	37.0	2.8	16.4
Fungi	0.3	0.6	0.3	0.6	0.1	—	0.6	0.1

Note. — Average of 10 determinations.



Figs. 1 and 2. Colonies of microorganisms isolated from mite alimentary canal. (1) Adult and (2) juvenile fed on algae.





Figs. 3 and 4. Colonies of microorganisms isolated from mite alimentary canal. (3) Adult and (4) juvenile fed on carrion.

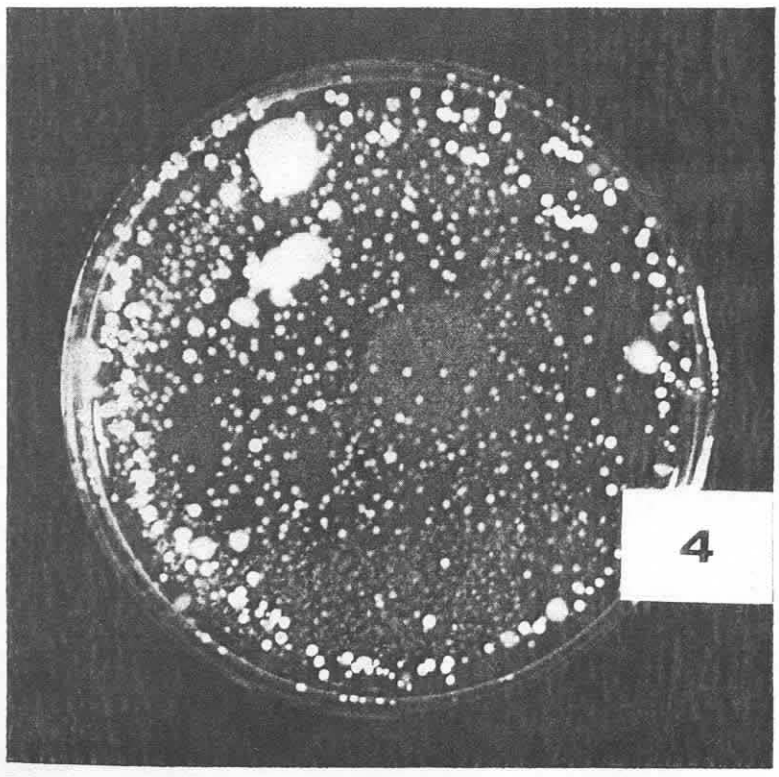


Table 2. Some characteristics of dominant microorganisms isolated from the alimentary canal of *Oppia nitens* feeding in nature

Specimens' stage	Group of microorganisms	Decomposition of					Action on					
		Gelatin	Starch	Cellulose	Pectins	Chitin	Gluc.	Fruc.	Lac.	Sacch.	Mal.	Glyc.
Adult	Bacteria											
	bacilli, G+	+	++	—	++	—	ac	ac	ac	ac	ac	ac
	short rods, G—	+	++	+	—	—	ac	—	—	—	—	—
	cocci, G+	—	+	—	+	—	ac	ac	ac	—	—	—
	Actinomycetes											
	Streptomyces sp.	++	+++	+	—	—	—	—	alk	—	—	—
	Nocardia sp.	++	+++	+	—	—	—	—	—	—	—	—
Juvenile	Bacteria											
	bacilli, G+, nonmotile	+	++	—	++	—	slight acid					
	bacilli, G+, motile	+++	+++	—	—	—	ac	ac	ac	ac	ac	ac
	short rods, G—	+	++	+	—	—	ac	—	—	—	—	—
	long rods, G—	—	+++	++	—	—	ac	ac	ac	ac	ac	ac
	cocci, G+	++	+++	++	—	—	—	alk	alk	alk	alk	—
	cocci, G—	+	++	—	+	—	ac	—	—	—	—	—
	Actinomycetes											
	Streptomyces sp.	++	+++	+	—	—	—	—	alk	—	—	—
	Nocardia sp.	++	+++	+	—	—	—	—	—	—	—	—
Dominant microorganisms in nature	Bacteria											
	bacilli, G+, aerobe	+	+++	++	+	—	ac	ac	ac	ac	ac	ac
	bacilli, G+, facult. anaerobe	+	+++	++	++	—	ac	ac	ac	ac	ac	ac
	long rods, G—	+	+++	++	+	—	—	—	—	—	—	alk
	long rods, G+	+	+++	—	++	—	ac	ac	—	ac	—	ac
	short rods, G+	+	++	+	—	—	—	—	—	—	—	—
	short rods, G+	+	—	—	—	+++	—	—	—	—	—	—
	short rods, G—	—	++	—	—	+++	—	—	—	—	—	—
	short rods, G—	+	+	—	++	—	ac	—	—	—	—	—
	cocci, G+	++	++	+++	—	—	—	alk	alk	—	—	—
	cocci, G+	+	++	+	—	—	ac	ac	alk	ac	—	—
	cocci, G—	+	++	++	+	—	ac.g	ac.g	ac.g	ac.g	ac.g	ac.g
	Actinomycetes											
	Streptomyces sp.	++	+++	+	—	—	—	—	alk	—	—	—
	Nocardia sp.	++	+++	+	—	—	—	—	—	—	—	—
	Yeasts	+	+	—	—	—	—	ac	—	ac	—	—

G+ = Gram positive
G— = Gram negative

+++ = very strong
++ = strong
+ = weak
— = none

ac = acid reaction
ac.g = acid + gas
alk = alkaline reaction
— = no action (no color change)

Table 3. Some characteristics of dominant microorganisms isolated from the alimentary canal of *Oppia nitens* fed on algae *(Protococcus viridis)*

Specimens' stage and food	Group of microorganisms	Decomposition of					Action on					
		Gelatin	Starch	Cellulose	Pectins	Chitin	Gluc.	Fruc.	Lac.	Sacch.	Mal.	Glyc.
Adult*)	Bacteria											
	long rods, G—	++	+++	+	—	—	—	—	alk	ac	—	ac
	long rods, G—	—	+	—	—	—	—	—	—	—	—	—
	rods, G—, facult. anaerobe	+	+++	—	—	—	ac	—	—	—	—	—
	Actinomycetes											
	Nocardia sp.	+	+++	+	—	—	—	—	—	—	—	—
	Streptomyces sp.	++	+++	+	—	—	—	—	alk	—	—	—
Dominant microorganisms on algae	Bacteria											
	long rods, G—	++	+++	+	—	—	—	—	alk	ac	—	—
	short rods, G+	+	—	—	++	—	slight acid					
	short rods, G+	+	—	—	—	+++	slight acid					
	short rods, G—	—	+++	—	—	+++	slight acid					
	Actinomycetes											
	Nocardia sp.	+	+++	+	—	—	—	—	—	—	—	—
	Streptomyces sp.	++	+++	+	—	—	—	—	alk	—	—	—

*) The alimentary microflora in juvenile forms was the same as in adult ones, but much more abundant and more active in cellulose decomposition.

G+ = Gram positive
G— = Gram negative

+++ = very strong
++ = strong
+ = weak
— = none

ac = acid reaction
alk = alkaline reaction
— = no action (no color change)

Table 4. Some characteristics of dominant microorganisms isolated from the alimentary canal of *Oppia nitens* fed on carrion

Specimens' stage and food	Group of microorganisms	Decomposition of					Action on					
		Gelatin	Starch	Cellulose	Pectins	Chitin	Gluc.	Fruc.	Lac.	Sacch.	Mal.	Glyc.
Adult	Bacteria											
	short rods, G—, facult. anaerobe	+	+++	—	—	+	slight acid					
	short rods, G—	+++	—	—	—	+++	—	—	—	—	—	alk
	Actinomycetes											
	Streptomyces sp.	+	+++	+	—	—	—	—	—	—	—	—
Juvenile	Bacteria											
	bacilli, G+	+++	+++	—	—	—	ac	ac	—	ac	ac	ac
	short rods, G+	++	+	—	—	+	slight acid					
	short rods, G—	+++	—	—	—	+++	slight acid					
	long rods, G—	+	++	—	—	++	slight acid					
	cocci, G+	++	++	—	—	+	—	—	—	—	—	—
	Actinomycetes											
	Streptomyces sp.	+	+++	+	—	—	—	—	—	—	—	—
Dominant bacteria of carrion	Bacteria											
	rods, G+	+++	—	—	—	++++	ac	—	—	—	—	—
	short rods, G—	+++	+++	—	—	—	slight acid					
	short rods, G—	+++	+	—	—	+++	ac	—	—	—	—	—
	cocci, G+	+++	+++	—	—	+	—	—	—	—	—	—

G+ = Gram positive
G— = Gram negative

+++ = very strong
++ = strong
+ = weak
— = none

ac = acid reaction
alk = alkaline reaction
— = no action (no color change)

Table 5. Some characteristics of dominant microorganisms isolated from the alimentary canal of *Oppia nitens* fed on human epidermis

Specimens' stage and food	Group of microorganisms	Decomposition of					Action on					
		Gelatin	Starch	Cellulose	Pectins	Chitin	Gluc.	Fruc.	Lac.	Sacch.	Mal.	Glyc.
Adult	Bacteria											
	long rods, G+	+++	—	—	+++	—	slight acid					alk
	short rods, G—	—	+++	—	—	—	slight acid					
	short rods, G—	++	—	—	—	—	alk	—	—	—	—	—
	Actinomycetes											
	Nocardia sp.	+++	+++	+	—	++	—	—	alk	alk	—	—
Juvenile	Bacteria											
	bacilli, G+	+++	+++	—	—	—	ac	ac	alk	ac	ac	ac
	long rods, G+	+++	+++	—	+	—	—	—	—	—	—	—
	short rods, G—	++++	—	—	—	+++	—	—	—	—	—	—
	short rods, G+	+++	—	—	+	—	—	—	—	—	—	—
	Actinomycetes											
	Nocardia sp.	+++	+++	+	—	++	—	—	alk	alk	—	—
	Streptomyces sp.	++	+++	+	—	—	—	—	alk	—	—	—
Dominant microorganisms on epidermis	Bacteria											
	short rods, G—	++++	++++	—	—	++++	—	—	—	—	—	—
	short rods, G+	+++	—	—	—	++	—	—	—	—	—	—

G+ = Gram positive
G— = Gram negative

+++ = very strong
++ = strong
+ = weak
— = none

ac = acid reaction
alk = alkaline reaction
— = no action (no color change)

Table 6. Fungi isolated from the alimentary canal of *Oppia nitens* fed on different foods

Specimens' stage	*Oppia nitens* fed			
	in nature	on algae	on carrion	on epidermis
Adult	none	*Penicillium viridatum* WEST.	none	*Penicillium spinulosum* THOM.
Juvenile	*Penicillium waksmanii* ZAL. *P. rosco-purpureum* DIERC.	*Penicillium viridatum* *Trichothecium roseum* LINK ex FR.	none	none

Dominant fungi in nature: *Penicillium waksmanii* ZAL., *Botrytis terrestris* JENS., *Phoma* cf. *humicola* GIL. et ABB., *Gliomastix murorum* (CORDA) HUG., *Mortierella* sp., *Phialophora fastigata* (LAG. LUND. et MEL.) CON., *Beauveria brongiartii* (SACC.) PETCH. Yeasts were also found in nature.

4. Conclusions

The results hitherto obtained justify the conclusion that the alimentary canal microflora in *Oppia nitens* definitely depends on the quality of food taken, but at the same time it is clearly distinct from the microflora of the feeding habitat. The bacterial microflora in the alimentary canal of these mites is abundant, while the fungal microflora is poor. This is probably due to the basic reaction of the alimentary canal contents of mites. This probability has been notified earlier by TERLIKOWSKI (1956).

The nature of the isolated bacteria suggests a symbiotic role for the microorganisms dwelling in the moss mites' alimentary canal. Probably they help the mites digest and absorb the complex organic compounds, and may also occasionally be subject to lysis and constitute additional protein food for their hosts.

Juvenile stages of *Oppia nitens* show more abundant and more active alimentary canal microflora than adult specimens, which points to their greater part in the decomposition of the soil organic matter.

5. Summary · Zusammenfassung

A study has been made of the alimentary canal microflora of juvenile and adult individuals of the polyphage *Oppia nitens*. The specimens used for study were derived from natural habitat (litter under yew-trees) and from culture (one group was fed on algae, the second on dead mites and Collembola, the third on the epidermis of the experimenter's fingers). A previously worked method was used (PRUSINKIEWICZ, STEFANIAK and SENICZAK 1975; STEFANIAK and SENICZAK 1976).

The results hitherto obtained justify the conclusion that the alimentary canal microflora in *Oppia nitens* definitely depends on the quality of food taken, but at the same time it is clearly distinct from the microflora of the feeding habitat. The bacterial microflora in the alimentary canal of these mites is abundant, while the fungal microflora is poor. This is probably due to the basic reaction of the alimentary canal contents of mites.

The isolated bacteria are symbiotic in the moss mites' alimentary canal and help the mites digest and absorb the complex organic compounds, and may also occasionally be subject to lysis and constitute additional protein food for their hosts.

Juvenile stages of *Oppia nitens* show more abundant and more active alimentary canal microflora than adult specimens, which points to their greater part in the decomposition of the soil organic matter.

Mikroflora des Verdauungskanals von *Oppia nitens* (Acarina, Oribatei)

Es wurde die Mikroflora des Verdauungskanals von juvenilen und adulten Individuen der polyphagen Art *Oppia nitens* untersucht. Die zur Untersuchung herangezogenen Individuen stammten aus natürlichen Umweltverhältnissen (Eibenstreu) sowie aus einer Kultur (eine Gruppe wurde mit Algen, die zweite mit toten Milben und Collembolen, die dritte mit Epidermis von menschlichen Fingern gefüttert).

Die Untersuchung wurde nach einer schon früher angewandten Methode durchgeführt (PRUSINKIEWICZ, STEFANIAK und SENICZAK 1975; STEFANIAK und SENICZAK 1976).

Die Mikroflora im Verdauungskanal von *Oppia nitens* ist deutlich durch die Qualität des angebotenen Futters geprägt, ist aber gleichzeitig wesentlich von der Mikroflora des Futterentnahmemilieus verschieden. Im Verdauungskanal dieser Milben kommt (wegen der basischen Reaktion des Darminhaltes) eine reiche Bakterienmikroflora und eine arme Pilzmikroflora vor.

Der Charakter der isolierten Bakterien spricht für eine symbiotische Rolle der im Verdauungskanal lebenden Mikroorganismen, welche den Moosmilben bei der Verdauung und Assimilation von komplizierten organischen Verbindungen behilflich sind und die außerdem nach gewisser Zeit verdaut werden, also als zusätzliche Eiweißnahrung dienen.

Die juvenilen Stadien von *Oppia nitens* zeichnen sich gegenüber den erwachsenen Individuen durch eine reichere und aktivere Intestinalmikroflora aus, was für einen größeren Anteil derselben an der Zersetzung der organischen Bodensubstanz spricht.

6. References

PRUSINKIEWICZ, Z., O. STEFANIAK i S. SENICZAK, 1975. Wstepne badania nad rola mikroflory przewodu pokarmowego wybranych gatunków mechowców (Oribatei, Acarina) w procesach humifikacji i mineralizacji ściółek leśnych. Materiały I Sympozium Zoologii Gleby, Rogów, PTG **1**, 107—116.

SENICZAK, S., 1972. A method of cultivation of soil mites in glass cultivation tubes with asbestos bottoms. Pol. Journ. Soil Sci. **5**, 127—132.

STEFANIAK, O., and S. SENICZAK, 1976. The microflora of the alimentary canal of *Achipteria coleoptrata* (Acarina, Oribatei). Pedobiologia **16**, 185—194.

TERLIKOWSKI, F., 1956. Próchnica a żyzność gleb. Nawozy organiczne t. III, PWRiL, Warszawa.

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